AMENDMENT TO THE SPECIFICATION

Please delete Paragraph [0002] and substitute new Paragraph [0002] therefore:

[0002] The present invention relates generally to rotary wing aircraft. In more specific aspects, the present invention relates to the mast that supports the rotary wing system of a rotary wing aircraft and methods for use associated therewith.

Please delete Paragraph [0003] and substitute new Paragraph [0003] therefore:

[0003] There are two types of heavier-than-air aircraft that achieve lift by movement through the air that relate to this art: (1) the airplane, and (2) the rotorcraft or rotary wing aircraft. The airplane has stationary wings that create lift when propelled through the air by a thrust mechanism such as a propeller or jet engine. The rotorcraft or rotary wing aircraft has blades that rotate to describe or form a rotor disc (the plane the rotor blades rotate in) positioned above the aircraft fuselage to create lift.

Please delete Paragraph [0004] and substitute new Paragraph [0004] therefore:

[0004] There are three types of rotorcraft that utilize a rotor blade to provide lift: (1) the helicopter, (2) the autogyro, and (3) the gyroplane. In the helicopter, the rotor blades are driven by an engine to rotate to form a plane of rotation which produces a resultant force vector defined as the vector sum of the rotor's lift and drag forces. This rotor disc provides a vertical lift vector or vertical thrust necessary to counteract the weight of the aircraft and thus provides for a vertical velocity. This rotor disc can be tilted on a supporting and/or rotating vertical mast. This tilting of the rotor disc results in a horizontal lift vector or horizontal thrust component, which counteracts drag in order to provide for a horizontal velocity. In the autogyro, vertical thrust is provided by a rotary wing or rotor forming a rotor disc and forward thrust is normally provided by a propeller. Autorotation is achieved by tilting the rotor disc back relative to the airflow so that some air flows up between the blades and through the rotor disc rather than down through the rotor disc as in a helicopter. As the air flows up through the rotor disc, the rotor disc is driven much like a windmill is driven by the wind. In the gyroplane, a rotor forming a rotor disc is used for vertical and slow speed flight, but at high speed cruising the rotor is ~~completely~~ unloaded (minimal lift) and the wing provides substantially all of the lift.

Please delete Paragraph [0009] and substitute new Paragraph [0009] therefore:

[0009] The winged helicopter and the winged autogyro, however, when in autorotation, can encounter excessive nose-up fuselage attitude in slow speed flight and/or flares, which will stall the wing. This is especially prevalent in ~~high~~ extreme aft center of gravity loading conditions. So, like the helicopter and autogyro, the winged rotorcraft can also have design and flying concerns because of extreme fuselage attitudes. Thus, recognized is the need for a means to manipulate the rotor disc such that the resultant force vector is maintained at or near the aircraft center gravity to prevent excessive moments causing excessive fuselage pitching, especially in slow speed flight and during acceleration and deceleration.

Please delete Paragraph [0011] and substitute new Paragraph [0011] therefore:

A rotorcraft such as a helicopter, an autogyro, or a gyroplane includes a fuselage, a center of gravity positioned ~~within~~ about the fuselage, a rotor assembly, either powered or unpowered, and tail section, with or without a tail rotor, connected to the fuselage, and a propulsion system including an engine mounted to the fuselage and either a turbine or a propeller connected to or driven by the engine. Depending on the configuration, the rotorcraft can also include a wing or wings mounted to the fuselage.

Please delete Paragraph [0012] and substitute new Paragraph [0012] therefore:

[0012] The rotor assembly includes a rotor having either a single or a plurality of rotor blades which can produce a resultant force vector which can pass through or near the center of gravity of the rotorcraft, and a spindle or swashplate to connect the rotor with a flight control assembly. The rotor assembly also includes a titling mast assembly having a tilting mast frame also connected to the spindle or swashplate to support the rotor and to provide some cyclic control. A mast control cylinder ~~is~~ provided to tilt the tilting mast assembly. Also included is a drive system having a gearbox and a rotatable driveshaft connected to and driven by the gearbox for driving the rotor.

Please delete Paragraph [0013] and substitute new Paragraph [0013] therefore:

[0013] The flight control assembly has both rotor blade pitch controls for uniformly changing pitch of the rotor blades and cyclic controls connected to the spindle or swashplate for changing the plane of rotation of the rotor both independent of the tilting mast frame and dependent upon the tilt of the tilting mast frame. The pilot can conventionally directly tilt the rotor through direct application of an input to a cyclic stick as with any other rotorcraft, can directly tilt the rotor by tilting the tilting mast frame, and can indirectly tilt the rotor through input applied to the cyclic control linkage resulting from a depending connection of the cyclic control linkage to the tilting mast frame. That is, the cyclic control linkage is pivotally connected to the spindle, the tilting mast frame, and the fuselage, such that the tilting mast frame and cyclic control tilt simultaneously.

Please delete Paragraph [0016] and substitute new Paragraph [0016] therefore:

In an embodiment of the present invention, the tilting of the mast can be accomplished through automated means. In this embodiment, a controller can receive input from an airspeed sensor and an angle of attack sensor to control the mast tilt to keep the fuselage at a desired pitch. This is especially useful in an gyroplane at low speeds in order to keep the wing at an angle of attack for a best lift-to-drag ratio. Additionally, the controller can tilt the tilting mast frame and cyclic control together to a predetermined position. This feature is particularly useful in a gyroplane at high speeds as rotor lift requirements decrease. Additionally, the controller can tilt the tilting mast frame and the cyclic control together during cruise and during landing as necessary to keep the fuselage substantially level, or at some desired pitch. This feature is particularly useful during cruise flight to reduce parasitic drag and during landing to eliminate the need for a large flare. Also, the controller can tilt the tilting mast frame and cyclic control together during flight to accommodate for in flight CG changes.

Please delete Paragraph [0026] and substitute new Paragraph [0026] therefore:

[0026] Referring to Figure 1, shown is a simplified model of a conventional fixed mast in a rotorcraft having a longitudinal axis passing through or near the design gross weight, and design configuration, aircraft center of gravity CG. The rotorcraft or rotary wing aircraft has blades that rotate to describe or form a plane of rotation ("rotor disc") and which produces a resultant force

vector V defined as the vector sum of the rotor's lift and drag forces. Under steady-state conditions, this resultant force vector V passes through or near the aircraft center of gravity CG. In the conventional fixed mast rotorcraft, movement of the rotor disc results in a corresponding movement of the resultant force vector V, with respect to the aircraft center of gravity CG, which further results in the formation of a moment which can cause large and sometimes undesirable fuselage attitude changes to again align the resultant force vector V with the rotorcraft center of gravity CG.

Please delete Paragraph [0027] and substitute new Paragraph [0027] therefore:

[0027] Referring to Figures 2-14, shown is a representative rotorcraft having an aircraft rotor assembly 20 according to an embodiment of the present invention. Referring ~~to~~ primarily to Figure 2, the representative rotorcraft includes a fuselage 21 having a longitudinal axis L, a center of gravity CG positioned within the fuselage 21, a wing or wings 23 mounted to the fuselage 21, a tail section 25 connected to the fuselage 21, and a propulsion system including an engine 27 mounted to the fuselage 21 and either a turbine (not shown) or a propeller 29 connected to or driven by the engine 27. The rotor assembly 20 includes a rotor 31 including either a single or a plurality of rotor blades 32 which can produce a resultant force vector V, and a spindle 33 to connect the rotor 31 with a flight control assembly 35. The rotor assembly 20 also includes a titling mast assembly 37 having a tilting mast frame 39 connected to the spindle 33 to support the rotor 31 and to provide a cyclic input, and a mast control cylinder 41 to provide mast tilt. Also included is a drive system 43 having a gearbox 45 and a rotatable driveshaft 47 connected to and driven by the gearbox 45 for driving the rotor 31. Advantageously, the flight control assembly 35, connected to the spindle 33 has both collective controls 49 (Figure 5) for uniformly changing pitch of the rotor blades 32 and cyclic controls 51 (Figure 3) for changing the plane of rotation of the rotor 31.

Please delete Paragraph [0028] and substitute new Paragraph [0028] therefore:

[0028] Referring to Figures 3-4, more specifically, the spindle 33, shown without its connections to the rotor 31 for clarity, includes a tubular shaft 53 with two opposite projecting arms 55, each arm 55 extending downward and radially outward from the upper end of the tubular shaft 53 and having an outwardly projecting pin 57 located at the end of the arm 55. Each 57 pin is shaped to

interface with a hub or other rotor attachment device (not shown) having corresponding pin apertures. The pins 57 serve to rotatably couple the spindle 33 to the rotor blade or blades 32. In the illustrated configuration, an axis passing through the center of the two pins 57 defines a pivot or teetering axis A, which allows for flapping of the rotor blades 32. Spindle 33 also includes a spindle lever 61 (described later) for translating cyclic input to the spindle 33. The spindle tilt is controlled by cyclic pushrods 63 which move in opposite directions for side-to-side rotor tilt, and in the same direction for fore-and-aft rotor tilt, and ~~is~~ are controlled by ~~a~~ slave cylinders 65 positioned in a medial portion of a pair of cyclic control rods 67 (described later).

Please delete Paragraph [0029] and substitute new Paragraph [0029] therefore:

[0029] The tilting mast assembly 37 includes a triangular shaped tilting mast frame 39. The mast frame 39 is formed of a plurality of forward and aft support legs 71, 73, longitudinal cross supports 75, and forward and aft lateral cross supports 77, 78, and rocker arms 79, with each lateral side of the tilting mast frame 39 preferably a mirror image of the other side of the mast frame 39. Conceptually, the tilting mast frame 39 connects the rotor 31 to the fuselage 21 of the rotorcraft such that forces on the rotor 31 are translated to the fuselage 21 through the tilting mast assembly 37. More specifically, each side of the tilting mast assembly 37 includes the forward support leg 71 and an aft support leg 73 which are connected at their uppermost ends at an apex 81. The apex 81 includes an aperture 83 which receives lateral pins 85 from a spindle yoke 87. Bearings (not shown), preferably needle bearings, or others known ~~as~~ and understood by those skilled in the art, are positioned within the apertures 83, to facilitate rotation. The forward lateral cross support 77 is connected adjacent the lower end of each of the forward support legs 71 by a means known to those skilled in the art. The forward lateral cross support 77 provides spacing between the pair of forward support legs 71 and overall added structural support to the tilting mast frame 39. The forward lateral cross support 77 also provides a rotatable connection point for the tilting mast frame 39 to the mast control cylinder 41 (described later).

Please delete Paragraph [0030] and substitute new Paragraph [0030] therefore:

[0030] A pair of preferably "V" shaped rocker arms 79 are positioned on either lateral side of the tilting mast assembly 39 to provide a lower tilting mast pivot location. Each rocker arm 79 has a pair of upper ends which connect adjacent to the lower ends of the forward and aft support legs 71, 73, respectively, by means known to those skilled in the art. Each rocker arm 79 also includes a rocker arm aperture 91 positioned at its respective lower apex 93. The lower apex 93 is connected to a gearbox mount 95, to form a mast pivot point. The gearbox 45 is connected to the fuselage 21, thus translating the rotor load to the fuselage 21. The gearbox mount 95 receives ~~includes~~ a pair of rocker arm shafts 97 received by rocker arm aperture 91. Each rocker arm aperture 91 also includes a bearing or bearing assembly, such as, for example, a pair of elastomeric bearings (not shown), which are received by the rocker arm apertures 91. Alternatively, the rocker arm shaft 97 can be connected either directly to the fuselage 21 or indirectly to the gearbox 45 using a mounting assembly (not shown).

Please delete Paragraph [0032] and substitute new Paragraph [0032] therefore:

[0032] A shaft 53 of spindle 33 turns on a double row ball bearing 99 inside spindle lever 61. Spindle 33 is coupled through an upper universal joint 101 to driveshaft 47, to lower universal joint 103, and finally to the gearbox 45 connected to or including a drive unit (not shown) such as, for example, a drive pulley or planetary gear arrangement. A power takeoff means such as an ~~in~~ input drive shaft or a drive belt (not shown) can be connected to the power plant or engine 27 ~~to~~ (Figure 2) which turns the drive unit. In this embodiment, universal joint 101 is necessary because driveshaft 47 is not aligned with spindle 33 when spindle 33 is tilted. Also, in the preferred configuration, driveshaft 47 is not aligned with the gearbox 45 when the tilting mast frame 39 is tilted. Spindle 33, universal joints 101, 103, driveshaft 47, and drive unit (not shown) rotate with the rotor 31. Universal joints 101, 103, can be plain or constant velocity universal joints. If they are plain universal joints, the rotor 31 should be positioned approximately normal to the longitudinal axis of the driveshaft 47, such that the angle between its rotational axis and the longitudinal axis of the driveshaft 47 is substantially equal to the angle between the longitudinal axis of the drive shaft 47 and the gearbox 45, until the power takeoff means (not shown), such as, for example, a prerotator, is disconnected from driving the driveshaft 47 to prevent damage to the universal joints 101, 103. Where the universal joints 101,

103, are of a constant velocity type, no such requirement exists and the rotor 31 may be pre-rotated or driven at any angle within the tilting ranges of the tilting mast assembly 37 and spindle 33.

Please delete Paragraph [0038] and substitute new Paragraph [0038] therefore:

[0038] Each forward support leg 71 of the tilting mast frame 39 can include at least one idler arm attachment 159 positioned at a medial point along each of the forward legs 71. The attachment 159 is preferably in the form of an aperture-rotatable pin and bearing arrangement, as illustrated, but can be in the form of a clevis to mate with rod end, or other hinge means known to those skilled in the art. An idler arm 161 having first and second ends 163, 165, is hinged freely by the first end by the idler arm attachment 159 to the medial portion of each of the forward legs 71. Both idler arms ~~when 61~~161 are preferably freely hinged about an axis E but can be alternatively hinged along separate axes. Each idler arm 161 includes a cyclic pushrod attachment 167 positioned at a medial point along the idler arm 161. The cyclic pushrod attachment 167 can be in the form of a clevis to receive the lower rod ends 157 of the cyclic pushrods 63 or aperture through the body of each idler arm 161 positioned in the medial portion of the each of idler arm 161 (as illustrated). Alternatively, the cyclic pushrod-idler arm connection can be in the form of an aperture with a pin or pin bearing connections, or other hinge means known to those skilled in the art. The second end 165 of each of the idler arms 161 is connected to a respective cyclic control rod 67 via an attachment such as a clevis or alternative arrangement, as described above, associated with the second end 165 of idler arm 161.

Please delete Paragraph [0042] and substitute new Paragraph [0042] therefore:

[0042] In the preferred configuration, this distance is selected such that the angular tilt of the rotor 31 through spindle 33 lags behind or is slightly less than tilt of the tilting mast frame 39, resulting in a shift of the resultant force vector V slightly away from the reference positioned at or near the aircraft center of gravity CG. This offset requires the pilot to make some manual correction to again position the resultant force vector V to pass through the desired position~~ed~~ at or near the aircraft center of gravity CG. This provides the pilot a "feel" that would not otherwise be provided if the resultant force vector V was perfectly maintained through the center of gravity CG. Operational implementation of the preferred configuration is described below.

Please delete Paragraph [0043] and substitute new Paragraph [0043] therefore:

[0043] Referring to Figure 7, for a jump takeoff, the titling mast assembly 37, via the tilting mast frame 39, is generally positioned adjacent its forward-most setting. Additionally, the rotor 31, via the spindle 33, is generally positioned near its center setting or even slightly forward of center. The positions of the tilting mast frame 39 and the rotor 31 combine to provide a forward thrust vector. The positioning of rotor 31 increases the forward thrust component or decreases the aft thrust component of the rotor resultant force vector V in order to provide forward thrust to the rotorcraft, or at least decrease the drag from the rotor 31. This is accomplished by tilting the resultant force vector V forward while minimizing the need to tilt the fuselage 21 forward, which would result in an unnecessary increase in parasitic drag or an undesirable fuselage attitude. Note, p~~P~~rior to takeoff, there is minimal fore and aft cyclic loading occurring as would exist during acceleration, cruise, or deceleration conditions as the takeoff is generally vertical. During a rolling takeoff, the titling mast assembly 37 can be initially configured in an aft setting similar to that illustrated for climb out (Figure 8) in order to provide additional takeoff lift followed by a more forwardly tilted configuration.

Please delete Paragraph [0044] and substitute new Paragraph [0044] therefore:

[0044] Referring to Figures 8-10 during takeoff, if the titling mast assembly 37 is not already in a forward position, as the aircraft begins to accelerate, the controller 113 (Figure 6) can automatically or the pilot can manually tilt the titling mast assembly 37 toward its forward tilted setting. More specifically, once the aircraft is in the air, responsive to a detection of a low

airspeed sufficient for climb out, and responsive to the angle of attack obtained from the angle of attack sensor 115, the controller 113 automatically or the pilot manually can adjust the mast tilt to attain and maintain an optimum angle of attack on the wings 23. For illustrative purposes, beginning from an aft tilted position (Figure 8), the controller (Figure 6) tilts the tilting mast frame 39 by causing the mast control cylinder 41 to retract the cylinder rod 105, applying force to the forward lateral cross support 77. This pulling force results in a rotational movement of the tilting mast assembly 37 about the mast pivot point (apex 93) which tilts the tilting mast frame 39, and correspondingly the spindle 33, rotor 31, and rotatable driveshaft 47.

Please delete Paragraph [0045] and substitute new Paragraph [0045] therefore:

[0045] In the preferred embodiment of the present mention, due to the spatial relationship of the pivot location of the cyclic control rods 67 (apertures 181) and the pivot location (apex 93) tilting mast frame 39, as the tilting mast frame 39 tilts forward, the rotor 31 via the spindle lever 87 will correspondingly tilt forward slightly. ~~The positioning of rotor 31 increases the forward thrust component or decreases the aft thrust component of the rotor resultant force vector V in order to provide forward thrust to the rotorcraft. This is accomplished by tilting the resultant force vector V forward while minimizing the need to tilt the fuselage 21 forward, which would result in an unnecessary increase in parasitic drag.~~ After movement of the tilting mast frame 39 by the controller 113, the resultant force vector V will, however, generally be positioned slightly forward of the CG (Figure 9) if the pilot does not move the cyclic control stick (not shown). This will require the pilot to manually move the cyclic control stick forward to maintain the resultant force vector V passing through the desired location at or near the aircraft CG as airspeed increases (Figure 10). If the pilot does not move the cyclic control stick forward, in the illustrated configuration, the aircraft will tend to pitch up as a result of the rotor force vector V passing in front of the aircraft CG. This pitching movement of the aircraft will cause the aircraft to tend to slow back down, providing inherent speed stability (dynamic stability).

Please delete Paragraph [0046] and substitute new Paragraph [0046] therefore:

[0046] Referring to Figures 6 and ~~11-13~~ 8-10, as the aircraft accelerates and climbs, responsive to a detection of the airspeed obtained from the airspeed sensor 115, and responsive to the angle of attack obtained from the angle of attack sensor 115, the controller 113 automatically, or the pilot manually, adjusts the tilting mast assembly 37 to compensate for in-flight CG changes, or to maintain a desired fuselage attitude (such as to aim weapons/sensors). In normal operation, the controller will preferentially maintain a fuselage attitude that results in an optimum angle of attack on the wings 23 (Figure 2). In most flight profiles, this input either from the controller 113 or the pilot results in a tilting ~~aft~~ forward of the tilting mast assembly 37, and thus the rotor 31, as the aircraft accelerates ~~generally in the reverse of that described above regarding takeoff,~~ in order to provide sufficient lift for the climb-out while maintaining the fuselage 21 in an attitude preferably providing the wing(s) 23 their best lift/drag ratio. For a jump takeoff, during climb-out, the tilting mast assembly 37 will initially tilt aft (Figures 11-13) to provide sufficient lift for the climb-out when the rotor 31 is producing most of the lift. If the rotorcraft was instead configured, such as that shown in prior art Figure 1, with a fixed mast and the wing incidence angle set for high speed cruise, the wing 23 would be in a stall at the high angle of attack needed by the rotor 31 when rotor 31 is producing most of the lift, as is the profile during the climb-out.

Please delete Paragraph [0051] and substitute new Paragraph [0051] therefore:

[0051] In the drawings and specification, there have been disclosed a typical preferred embodiment of the invention, and although specific terms are employed, the terms are used in a descriptive sense only and not for purposes of limitation. The invention has been described in considerable detail with specific reference to these illustrated embodiments. It will be apparent, however, that various modifications and changes can be made within the spirit and scope of the invention as described in the foregoing specification. For example, the illustrated embodiment depict nonrotating cyclic linkage interfaced with a tilting spindle to control the rotor cyclic. Also illustrated was a tiltable mast including a driveshaft for driving the rotor having pitch controls positioned therethrough. A similar mechanism, however, could also be used on a more conventional swashplate control having either rotating or nonrotating components providing cyclic and/or collective inputs to the rotor disc. Also for example, ~~of~~ the rotor head was

illustrated of a type using a teetering hinge. Other rotorhead types such as a fully articulated system are also within the scope of the present invention.